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Cosmic Physics Cosmic Chemistry Cosmic Biology Supercelestial Structure —— Superspin Spinning Law and Superspin Field Cosmic Matter 2025V1.3 Revised Global Network Multilingual Edition E-book

Cosmology

The Origin and Development of Cosmology

As a discipline that studies the origin, structure and evolution of the universe, cosmology has a profound and rich development history. From ancient astronomical observations to modern physical theory construction, cosmology has gone through several important stages of development.

Ancient Cosmology

In ancient times, humans formed a simple view of the universe by observing the sky. For example, the ancient Babylonians established the theory that the moon revolves around the earth by observing the phases of the moon and the movement of the planets. Ancient Greek astronomers such as Aristarchus and Ptolemy proposed the geocentric theory, believing that the earth is at the center of the universe.

Copernican Principle and Newtonian Mechanics

Copernicus proposed the heliocentric theory, which challenged the

long-standing geocentric theory and laid the foundation for later cosmological research. Newton's law of universal gravitation further explains the laws of celestial motion and provides an important theoretical basis for the development of cosmology.

The birth of modern cosmology

Modern cosmology originated in the early 20th century. Einstein's general theory of relativity predicted the expansion of the universe and the existence of black holes. This theory not only changed people's understanding of the universe, but also pointed out the direction for subsequent cosmological research.

The development of cosmological physics

Cosmological physics is the science of studying physical phenomena and processes in the universe. Its development process is also full of innovation and challenges.

Big Bang theory

The Big Bang theory is currently the most widely accepted theory of the origin of the universe. According to this theory, the universe originated from an extremely small and extremely hot point about 13.8 billion years ago, and then experienced a huge explosion, starting the expansion process of the universe.

Cosmic microwave background radiation

The cosmic microwave background radiation is the afterglow left after the Big Bang, and its uniform distribution characteristics provide important supporting evidence for the Big Bang theory.

Dark matter and dark energy

The discovery of dark matter and dark energy is a major progress in modern cosmology. Dark matter is a substance that cannot be directly observed, but plays an important role in the formation of cosmic structure. Dark energy is a mysterious force that drives the accelerated expansion of the universe.

Development of astrochemistry

Astrochemistry is the science that studies the chemical composition and evolution of celestial bodies. Its development process involves detailed studies of stars, planets and other celestial bodies.

Evolution of stars

The birth, aging, disease and death of stars are the main stages in their evolution. Through the study of stars, scientists can understand the life cycle of stars of different masses and their impact on the abundance of chemical elements in the universe.

Formation of planetary systems

The formation of planetary systems is one of the important contents of astrochemical research. Studies have shown that planetary systems are usually formed shortly after the formation of stars, and their composition and structure are affected by the original nebula material5.

Development of cosmic structure

Cosmic structure studies the large-scale structure and evolution of the universe. Its development process covers the study of the overall structure from galaxies to the universe.

Classification and structure of galaxies

The classification of galaxies mainly includes elliptical galaxies, spiral galaxies and irregular galaxies. Through the study of different types of galaxies, scientists can understand the structure and evolution of the universe.

Formation of large-scale structure of the universe

The large-scale structure of the universe is a huge network composed of galaxy clusters and superclusters. The formation and evolution of these structures is one of the important contents of cosmological research.

In summary, the development of cosmology, cosmological physics, astrochemistry and cosmological structure is full of innovation and challenges. The development of these disciplines has not only promoted the deepening of human understanding of the universe, but also pointed out the direction for future cosmological research.

● Unsolved mysteries in cosmological research

I. The mystery of the origin and early evolution of the universe

Unsolved mysteries of the Big Bang theory

Although the Big Bang theory is the mainstream model to explain the origin of the universe, there are still many core problems:

State before the Big Bang: According to the search results, the existence of the inflation period caused the information before the Big Bang to be erased, and the current physical theory cannot explain the triggering and termination mechanism of inflation.

Uniformity of the universe: Why is the early universe highly uniform on a large scale? Although the inflation theory can partially explain

it, the initial conditions and termination reasons of inflation are still mysteries.

Hubble constant contradiction: There is a difference between the Hubble constant values measured by the supernova distance measurement method and the cosmic microwave background radiation (CMB) (about 70 vs. more than 60), which may indicate new physical laws or observational biases.

Conflict between the age of the universe and the expansion rate

Recent studies have shown that there is a contradiction between the age of the universe and the expansion rate calculated by different methods (such as type Ia supernovae and CMB), suggesting that the standard cosmological model may be incomplete.

2. The nature of dark matter and dark energy

The identity and role of dark matter

Dark matter accounts for about 27% of the total mass of the universe, but its particle properties (such as whether it is composed of weakly interacting massive particles WIMPs) have not been directly detected.

Driving mechanism of dark energy

Dark energy is considered to be the driving force of the accelerated expansion of the universe, accounting for about 68% of the total mass-energy of the universe. Its essence may be vacuum energy (cosmological constant) or some dynamic field (such as the fifth force), but there is no conclusion yet.

Dark matter-dark energy interaction

Some theories suggest that there may be a coupling relationship between the two, but observational data has not yet supported this hypothesis.

3. Unsolved Phenomena in the Structure and Evolution of the Universe

Mechanism of Formation of Galactic Bulbs

A study in 2024 found that bulge structures exist in early universe starburst galaxies, but their formation process (such as how violent stellar activity triggers bulge aggregation) still needs further verification.

Fast Radio Bursts (FRBs) and Dark Flows

The sources of FRBs (such as neutron star mergers or magnetar explosions) have not yet been clarified, and the periodic signals of some FRBs (such as a 16-day repetition period) have added to the complexity.

Cosmic Dark Flow: CMB temperature differences suggest abnormal flows of large-scale structures, which may challenge cosmological principles.

Black Hole Information Paradox

Do black holes devour information permanently? The contradiction between quantum mechanics and general relativity on this issue has not yet been reconciled.

4. Challenges to Basic Physical Laws

The Unification of Gravity and Other Forces

The description of gravity in a quantum framework (such as string theory or loop quantum gravity) has not yet been completed, and the multidimensional space hypothesis has not been verified.

Origin of the arrow of time

Can the second law of thermodynamics (entropy increase) explain the unidirectionality of time? The cause of the low entropy state in the early universe remains a core problem.

Matter-antimatter asymmetry

The Big Bang should have produced equal amounts of matter and antimatter, but actual observations show that matter is overwhelmingly dominant. Research on neutrino behavior (such as CP violation) may be a breakthrough.

V. Extreme celestial bodies and phenomena

Quark stars and white holes

Quark stars (composed of quark matter) exist in theory, but have not yet been confirmed by observation2.

White holes (celestial bodies opposite to black holes) are mathematical solutions to Einstein's equations, but there is a lack of observational evidence9.

Absolute zero and Planck temperature

Quantum mechanics prohibits reaching absolute zero (-273.15℃), while Planck temperature (about 1.4×10^{32}K) only appears at the moment of the Big Bang, and its physical meaning is still unclear.

The unsolved mysteries of cosmology profoundly reflect the

boundaries of human cognition. From the search for dark matter to the exploration of multidimensional space, each breakthrough may reshape our understanding of the universe. In the future, with the help of more powerful observational tools (such as the China Sky Survey Space Telescope) and theoretical innovation, these mysteries may be gradually unveiled.

Cosmology is the study of the large-scale structure and evolution of the universe. Since the Copernican principle, cosmology has undergone a transition from classical cosmology to modern cosmology. Modern cosmology relies on great progress in observational cosmology, including cosmic microwave background radiation, distant supernovae, and galaxy redshift surveys.

● Main theoretical framework

Standard model of cosmology: This model believes that the universe contains a large amount of dark matter and dark energy, whose properties are currently unclear, but consistent with many observations.

General relativity: Einstein's theory describes gravity as a geometric property of space and time, which is crucial to the development of cosmology.

Latest research findings

Irregular accelerated expansion of the universe: A research team from the University of Canterbury in New Zealand analyzed the light curves of type Ia supernovae and proposed that the universe may not be actually accelerating at the physical level, but rather an observational effect caused by the way people calibrate time and distance for an inhomogeneous universe.

Cosmology

Cosmology studies matter and energy in the universe and the interactions between them.

Quantum mechanics and plasma physics: These fields provide a theoretical basis for understanding elementary particles and energy processes in the universe.

Latest research findings

The largest atomic gas structure in the universe: An international team led by Xu Cong, a researcher at the National Astronomical Observatory of the Chinese Academy of Sciences, found that this is the largest atomic gas structure detected in the universe so far, 20 times larger than the Milky Way.

Astrochemistry

Astrochemistry studies the chemical composition of various celestial bodies in the universe and their evolution.

Main theoretical frameworks

Element abundance and nucleosynthesis: These theoretical frameworks help understand the origin and evolution of elements in stars and other celestial bodies.

Latest research findings

Soft X-ray signals from early cosmic explosions: China's Tianguan satellite detected soft X-ray signals from early cosmic explosions, which is the first time that humans have detected such signals.

Cosmic super-astronomical structure

Cosmic super-astronomical structure studies the structure and evolution of supermassive celestial bodies in the universe.

Main theoretical framework

Galaxy dynamics: Studies the interactions within and between galaxies and their impact on galaxy evolution.

Latest research findings

Low-density atomic gas structures outside Stephan's Quintet: The formation of these structures may be related to the interaction history of galaxies during their early formation.

Particle physics

Particle physics studies elementary particles and their interactions.

Main theoretical framework

Standard model: Describes the elementary particles and forces in the universe (such as electromagnetic force, weak force and strong force), and is one of the most successful physical theories at present.

Latest research findings

Challenge of dark energy: Through the analysis of type Ia supernovae, some studies have challenged the existence of dark energy and proposed that the universe may expand in different ways.

Cosmic biology

Cosmic biology studies the origin and evolution of life in the

universe.

Main theoretical framework

Origin of life: Explore how life forms and develops in the cosmic environment.

Latest research findings

Relationship between gamma-ray bursts and fast X-ray transients: These findings help understand the strongest explosive phenomena in the universe and their possible biological significance.

The above is an analysis of the main theoretical frameworks of cosmology, cosmology, astrochemistry, cosmic super-astronomical structure, particle physics and cosmology and

Alternative theories of the cosmological principle

The cosmological principle is the cornerstone of modern cosmology, which holds that the universe is uniform and isotropic on a large scale. However, with the accumulation of observational data and the development of theory, multiple alternative theories have been proposed to challenge or modify this principle. The following are the current main alternative theories and their basis:

I. Multiverse and eternal expansion theory

Core view: The universe produces multiple independent regions ("cosmic bubbles") through eternal expansion, and the physical laws and constants of each region may be different.

Challenge to the cosmological principle: Although each cosmic bubble may satisfy local uniformity, the overall multiverse presents non-uniformity and directional differences on a larger scale.

Theoretical basis: Based on the combination of quantum field theory and general relativity, dark energy is introduced to drive the continuous expansion of different regions.

Current status: It is still a theoretical hypothesis and lacks direct observational evidence, but it is supported by some inflation models.

2. Modified gravity theory

Core idea: By modifying general relativity or Newtonian dynamics, the assumption of dark matter/dark energy is replaced, thereby changing the dynamics of large-scale structures.

f(R) gravity theory

By adjusting the gravitational term in the space-time geometry equation, the accelerated expansion of the universe is explained without the introduction of dark energy.

Limitations: It is necessary to fine-tune the parameters to match the observations, and the self-consistency of the theory needs to be verified.

Cosmological extension of modified Newtonian dynamics (MOND)

Gravity is modified on the galaxy scale to replace dark matter, but its relativistic version needs to be combined with additional field theory tools such as scalar fields to match the cosmic microwave background (CMB) data

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Current situation: MOND performs well in galaxy rotation curves, but the observation data of distant binary stars (such as the results of

Gaia satellite DR3) exclude the classical MOND7 with a confidence level of 16σ. The latest model attempts to be compatible with observations through field coupling mechanisms.

III. Quantum cosmological model

Core viewpoint: Redefine the space-time structure through quantum gravity theory (such as loop quantum gravity), eliminate singularities and change the assumption of large-scale uniformity.

k=-1 quantum cosmological model: propose a non-flat space topology (open universe), explore the possibility of singularity rebound through quantized gravitational Hamiltonian constraints6.

Impact on uniformity: Quantum fluctuations may cause residual non-uniformity in the early universe, which needs to be further verified by combining primordial perturbation observations.

IV. Artificial design universe hypothesis

Core viewpoint: The universe is designed by advanced civilizations in the laboratory, and the physical laws are artificially set.

Theoretical basis: Based on unsolved mysteries such as dark energy and dark matter, it is believed that the high precision of natural constants implies the possibility of design.

Challenge: Lack of falsifiability, currently only philosophical speculation, but inspiring exploration of the nature of physical laws.

V. Cyclic cosmology

Core view: The universe undergoes periodic expansion and contraction, and enters a new cycle after each "big bang".

Impact on uniformity: The contraction phase may lead to the accumulation of non-uniform distribution of matter, but the expansion phase may restore uniformity.

Current situation: The entropy increase problem and the physical mechanism of the contraction phase need to be solved, and a complete theoretical framework has not yet been formed.

VI. Steady state theory (historical replacement theory)

Core view: The universe continues to expand and spontaneously produces matter to maintain the average density unchanged, challenging the assumption of uniformity in time.

Current situation: It has been abandoned by the mainstream due to contradictions with CMB observations (such as lack of evolutionary evidence), but it is still studied as a historical theory.

Summary and Outlook

Current mainstream cosmology is still based on the cosmological principle (such as the ΛCDM model), but alternative theories continue to explore in the following directions:VI. Steady State Theory (Historical Alternative Theory)

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Summary and Outlook

Current mainstream cosmology is still based on the cosmological principle (such as the ΛCDM model), but alternative theories continue to explore in the following directions:

Modified gravity and dark energy models: compatibility with galaxy-scale observations needs to be resolved.

Quantum gravity and multidimensional space-time: Theories such as loop quantum gravity may provide a new perspective on the inhomogeneity of the early universe.

Multiverse and observational verification: In the future, it may be indirectly verified through cosmic microwave background polarization or gravitational wave detection8.

Although some theories (such as classical MOND) have been ruled out by observations, new modified models and quantization schemes still provide rich possibilities for exploring the boundaries of the cosmological principle.

●The exploration of the universe is a field full of challenges and unknowns. Human beings' understanding of the universe is constantly improving, but there are still many unresolved problems. The following is an analysis and discussion of several issues you mentioned:

1. The evolution model, structure, initial and final states of the universe

• Cosmic evolution model: The most widely accepted cosmic evolution model is the Big Bang theory, which holds that the universe began to expand from an extremely hot and dense state about 13.8 billion years ago. As the universe cooled and expanded, matter gradually formed structures such as stars, galaxies, and

galaxy clusters.

• Cosmic structure: The large-scale structure of the universe presents a complex network distribution, which is interwoven by filaments composed of galaxies to form superclusters. For example, the recently discovered "Quipu" structure is one of the largest structures in the known universe, spanning about 1.3 billion light years.

• The initial and final states of the universe: Regarding the initial state of the universe, the Big Bang theory holds that the universe originated from an extremely high temperature and high density state. As for the final state of the universe, there are currently multiple hypotheses, including that the universe may continue to expand until matter becomes rarefied (the "Big Freeze"), or that it may re-collapse under certain conditions (the "Big Crunch").

2. The finiteness and infinity of the universe

• Finiteness: According to the Big Bang theory, the universe began to expand from a finite initial state, and the diameter of the observable universe is currently about 93 billion light years. However, this does not mean that the actual size of the universe is only this large, because the universe may continue to extend beyond the range we cannot observe.

• Infinity: Some theories believe that the universe may be infinite, which means that there are infinite amounts of matter and structure in the universe. If the universe is infinite, then somewhere in the universe there may be a planet exactly like the Earth.

3. Comparison of Earth's physics and chemistry with the Milky Way and extragalactic galaxies

• Consistency of physical and chemical laws: From current observations and theories, the physical and chemical laws of different regions in the universe are the same. For example, the formation and evolution of stars follow similar physical laws in both the Milky Way and extragalactic galaxies. The sun, like other stars, releases energy through nuclear fusion.

• Consistency of material composition: Matter in the universe is mainly composed of elements such as hydrogen and helium, which are widely present in the Milky Way and extragalactic galaxies. However, the abundance of elements in different galaxies may vary, depending on the evolutionary history of the galaxy.

4. Limitations of human cognition and future exploration

• Cognitive limitations: Human cognitive ability is indeed limited, and our current understanding of the universe is just the tip of the iceberg. Despite this, scientific progress continues to promote our in-depth understanding of the universe.

• Future exploration: With the development of technology, such as the emergence of more powerful telescopes and detectors, humans may have more major discoveries in the future. For example, the study of dark matter and dark energy may reveal deeper mysteries of the universe.

In short, the exploration of the universe is a long and difficult process. Humans do seem small in front of the universe, but through continuous efforts and innovation, we are expected to gradually uncover the mystery of the universe.

● Comprehensive analysis of cosmic theories and models

I. The dispute between the finite and infinite universe

1. **The closed loop hypothesis of the finite universe

Some theories believe that the universe may be finite but boundless, similar to a closed ring structure. If you continue to move in a certain direction, you may eventually return to the origin. This model requires the size of the universe to be at least 250 times the current observable range, but its curvature cannot be verified at present due to the limitations of observation technology. Einstein's theory of space-time curvature supports this hypothesis, but the flat universe model is still the mainstream.

2. Mathematical possibility of an infinite universe

If the universe is infinite, then theoretically there are regions with exactly the same atomic arrangement, and it is even possible to copy another Earth and "you". However, the premise of this inference is that the universe contains infinite matter, but the finiteness of the total amount of initial matter in the Big Bang singularity may negate this conclusion. In addition, the accelerated expansion of the universe causes the recession speed of distant galaxies to exceed the speed of light, making it impossible for humans to observe its boundaries forever, forming the difference between the "observable universe" (radius of about 46 billion light years) and the real universe.

3. The boundary between philosophy and science

The concept of infinity challenges the limitations of human cognition. Scientists generally believe that the true size of the universe may be far beyond the observable range, but the answer of "finite" or "infinite" may never be verified by experiments.

2. Model and structure of cosmic evolution

1. Big Bang and inflation theory

The universe began with a high-density singularity 13.8 billion years ago. After inflation, it expanded rapidly to form a uniform space-time structure. The cooling process after inflation caused matter to differentiate and form galaxies and stars. However, the state of the universe before inflation remains an unsolved mystery. Some theories speculate that it may be in a quantum fluctuation or higher-dimensional form.

2. The role of dark energy and dark matter

Dark energy (accounting for 68% of the total energy of the universe) drives the accelerated expansion of the universe, while dark matter (27%) affects the distribution of galaxies through gravity. The two together shape the large-scale structure of the universe, but its essence remains one of the biggest mysteries in physics.

3. Virtual information model and evolution process

Some theories propose that there are three basic states of the universe: physical entity, information model and virtual information model. Virtual information is potential "nothingness", which is transformed into observable entities and information through interaction. This process is considered to be the core mechanism of cosmic evolution.

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III. Initial and final states of the universe

1. Initial state: singularity and quantum gravity problem

The extreme conditions of the Big Bang singularity (infinite density

and temperature) make general relativity invalid, and quantum gravity theory is needed to explain it. String theory, loop quantum gravity, etc. attempt to describe this stage in a unified way, but no consensus has been reached.

2. Final state: heat death and big freeze

If the universe continues to expand, the distance between galaxies will increase infinitely. After the star fuel is exhausted, the universe will fall into a low-temperature, dark "heat death" state. This outcome is based on the law of entropy increase, but the nature of dark energy may change this prediction.

IV. The consistency of physical and chemical laws in the universe

1. Similarity between the earth and extragalactic galaxies

Current observations show that the physical and chemical laws (such as element abundance and gravitational constant) of the Milky Way and distant galaxies are basically consistent. For example, spectral analysis shows that other galaxies have the same elements as the earth, such as hydrogen and helium.

2. The controversy over "copies" in an infinite universe

If the universe is infinite and matter is infinite, theoretically there may be planets that are exactly the same as the Earth. However, if the initial matter is finite (limited by the Big Bang singularity), this possibility will be denied. In addition, the multiverse theory believes that different universes may have very different physical laws, but humans cannot observe them.

The various theoretical hypotheses and evolutionary models of the universe are indeed dazzling. From the Big Bang theory to the

multiverse hypothesis, from the initial state to the final state of the universe, from finite to infinite, scientists have proposed many models and theories to explain the cosmic phenomena we observe.

1. The initial and final states of the universe: The Big Bang theory believes that the universe originated from an extremely hot and dense state, and the final state of the universe may be heat death, big tear, big compression or other forms, all of which depend on factors such as the density of the universe and the nature of dark energy.

2. The finiteness and infinity of the universe: This issue has not yet been determined. According to current observational data, the universe may be flat, which means it may be infinite, but this may also be because our observation range is limited and we cannot see the full picture of the universe.

3. Unsolved puzzles: Indeed, there are many puzzles in cosmic science, such as the nature of dark matter and dark energy, the lack of a quantum gravity theory, and the accelerated expansion of the universe. These problems require new theories and technologies to solve.

4. Comparison of Earth's physics and chemistry with the rest of the universe: The physicochemical processes on Earth are universal in the universe because they follow universal laws of nature. However, due to differences in environmental conditions, such as temperature, pressure, chemical composition, etc., the physicochemical processes on other galaxies and celestial bodies may be different.

Several considerations about Earth's physics and chemistry with the rest of the universe:

Universality: Basic physical laws, such as the laws of

thermodynamics, the principles of quantum mechanics, the laws of electromagnetism, etc., are universally applicable in the universe. Therefore, the physicochemical processes on Earth are in principle the same as elsewhere in the universe. Speciality: The Earth is special in that it has liquid water, a suitable temperature range, and abundant chemical elements, which support the existence of life. These conditions may be different in other galaxies or celestial bodies.

Environmental differences: Different planets and galaxies may have different environmental conditions, such as extreme temperatures, pressures, radiation levels, etc., which affect physical and chemical processes.

Matter distribution: The distribution of matter in the universe may be different in different regions, which will affect the synthesis and existence of chemical elements.

In the future, humans may develop more advanced observation techniques and theoretical frameworks to solve current scientific problems. Here are some possible prospects:

More in-depth observations: As technology develops, future telescopes and detectors may reveal more secrets of the universe, including the nature of dark matter and dark energy.

New theoretical discoveries: New theoretical breakthroughs may emerge in physics, such as a complete theory of quantum gravity, which will help us better understand the initial and final states of the universe.

Space exploration: Humans may explore farther into the universe and directly study the physical and chemical processes of other galaxies and celestial bodies.

The answer to the origin of life: We may have a deeper understanding of the origin of life and the distribution of life in the universe.

In short, there is really no ultimate point in the exploration of cosmic science. It is a process of continuous progress. Although human cognitive ability is limited, our wisdom and creativity are unlimited, which will drive us to continue to explore and discover in the years to come.

V. Limitations of human cognition and future prospects

1. The gap between observation and theory

Limited by the speed of light and the expansion of the universe, the range of human observability only accounts for a very small part of the real universe. Unsolved problems such as dark matter and dark energy reveal the shortcomings of existing theories.

2. Time scale and continuation of civilization

Even if there are technological breakthroughs in the future, the accelerated expansion of the universe may lead to future generations being able to observe only the Milky Way, returning to the cognitive limitation of "the Milky Way is the entire universe". The duration of civilization may become a key constraint in exploring the truth of the universe.

●The core issues of cosmic science (such as finiteness and universality of physical laws) are still unresolved, but it is these unknowns that drive humans to continuously break through the boundaries of cognition. The physical and chemical laws of the earth are consistent within the observable range, but the vastness and

complexity of the universe are far beyond imagination. Perhaps as Hawking said: "The universe does not need boundaries, it is self-sufficient and complete." Future exploration may rely on higher-dimensional theoretical frameworks, or may have to wait for another leap in civilization tens of thousands of years later.

The evolution of structure is orderly, disordered, chaotic or disordered, dark matter, dark energy, supergiant, super celestial structure, the continuous discovery and change of particles and chemical elements, whether the domain of earth structure is completely homogeneous or heterogeneous with natural cosmic celestial bodies, the blind spots of human vision and the nature of the natural universe, the research, observation, experiment, detection, finite and infinite, natural philosophy, philosophy of science, cosmology, cosmological physics, particle physics, astrochemistry, astrobiology, super celestial structure, etc. are closely related, but after all, they are not the same. The history of the universe is trillions of years, and the human beings on earth are only millions of years. To be precise, there is only a very short history of less than 10,000 years with written records. Although science and technology have made great strides, humans have made major discoveries and explorations, such as Newtonian mechanics, quantum mechanics, particle physics, etc., as well as landing on the moon and Mars, which show the great power of human wisdom and rationality.

The evolution of the material structure of the universe, the role of dark matter and dark energy, the discovery of particles and chemical elements, and the similarities and differences between the earth's structure and cosmic celestial bodies are the core issues in cosmology and astrophysics. The following is a comprehensive analysis of these issues from multiple perspectives:

I. The evolution of the material structure of the universe: from chaos to order

1. The formation of the large-scale structure of the universe

The material distribution of the universe is not random, but presents a "fibrous" mesh structure, called the "cosmic web". This structure originates from the density fluctuations and gravitational effects of the early universe. Dark matter attracts ordinary matter through gravity to form structures such as galaxies and galaxy clusters, while dark energy accelerates the expansion of the universe and affects the evolution of the structure.

2. Evolution from chaos to order

The early state of the universe was highly uniform, but quantum fluctuations were amplified during inflation, forming "seeds" with uneven density. These seeds gradually evolved into galaxies and galaxy clusters under the action of gravity, and finally formed today's large-scale structure of the universe.

3. The balance between order and disorder

Although the universe as a whole tends to be ordered (such as the formation of galaxies and galaxy clusters), local chaotic phenomena still exist, such as supernova explosions and black hole accretion. This balance between order and disorder is the core feature of cosmic evolution.

2. The role of dark matter and dark energy

1. Gravitational support of dark matter

Dark matter accounts for 27% of the total mass of the universe. It

maintains the structure of galaxies and galaxy clusters through gravity. For example, the abnormal phenomenon of galaxy rotation curves shows that the existence of dark matter is the key to the stability of galaxies.

2. Accelerated expansion of dark energy

Dark energy accounts for 68% of the total energy of the universe. It manifests as a repulsive force that drives the accelerated expansion of the universe. The interaction between dark energy and dark matter determines the ultimate fate of the structure of the universe.

3. Unsolved mysteries of dark matter and dark energy

Although the existence of dark matter and dark energy has been widely accepted, their nature remains an unsolved mystery. Scientists have indirectly detected them through gravitational lensing, cosmic microwave background radiation and other means, but direct observation still faces huge challenges.

3. Discovery and changes of particles and chemical elements

1. Element synthesis in the early universe

After the Big Bang, light elements (such as hydrogen and helium) were first formed. Subsequently, nuclear fusion inside stars produced heavier elements, and supernova explosions spread heavy elements into the universe, providing the material basis for the formation of planets and life.

2. Progress in particle physics

With the development of high-energy physics

2. The discovery and changes of particles and chemical elements

• Progress in particle physics: From the discovery of atoms to the confirmation of elementary particles such as quarks and leptons, particle physics continues to go deeper into the microscopic world. Every discovery of particles has promoted our understanding of the nature of matter. For example, the discovery of the Higgs boson verified the integrity of the standard model.

• Evolution of chemical elements: The formation of chemical elements mainly occurs inside stars and during supernova explosions. Starting with hydrogen and helium, heavier elements are formed through nuclear fusion and nuclear synthesis. The distribution of chemical elements on Earth is the result of the synthesis and distribution of cosmic elements, but the special environment of the Earth (such as plate tectonics and the presence of water) also makes the distribution of chemical elements on Earth unique.

3. Homogenization and heterogeneity of the Earth's structure and cosmic bodies

• Homogenization: From the perspective of material composition, the chemical elements on Earth are consistent with those in the universe. For example, elements such as carbon, oxygen, and silicon on Earth are widely present in the universe. The formation of the Earth is also part of the aggregation and evolution of cosmic matter.

• Heterogeneity: The structure and environment of the Earth are unique. The Earth's plate tectonics, atmosphere, liquid water and other features make it very different from most celestial bodies. This heterogeneity is the basis for the existence of life on Earth and an important part of Earth science research.

4. Blind spots in human vision and the nature of the natural universe

• Blind spots in vision: Despite the great progress made in human science, many aspects of the universe are still beyond our understanding. For example, the nature of dark matter and dark energy, the unified theory of quantum gravity, the origin and ultimate fate of the universe, etc. These blind spots remind us that scientific exploration is an endless process.

• The nature of the natural universe: The nature of the universe may include the unity of order and disorder, determinism and randomness, and finiteness and infinity. Our understanding of the universe is gradually deepening, and every scientific breakthrough may change our understanding of the nature of the universe.

5. Interdisciplinary intersection and integration

• Multidisciplinary association: Cosmology, physics, chemistry, astronomy, biology and other disciplines intersect and integrate with each other. For example, astrochemistry studies chemical processes in the universe, and astrobiology explores the origin and distribution of life in the universe. This interdisciplinary approach helps us understand the universe from different perspectives.

• The relationship between science and philosophy: Scientific exploration is not only the description and explanation of natural phenomena, but also involves profound philosophical thinking. Natural philosophy and philosophy of science help us understand the nature of science, the limitations of scientific methods, and the relationship between science and human society.

6. Comparison between human history and cosmic history

• The short history of mankind: Human history is extremely short on

the time scale of the universe. Nevertheless, human wisdom and rationality have enabled us to achieve great scientific achievements in a short period of time. From Newtonian mechanics to quantum mechanics, from the earth to the moon and Mars, human exploration spirit and scientific ability are amazing.

• Future exploration: Despite our many achievements, the mysteries of the universe are still endless. Future scientific exploration will continue to expand our horizons and help us better understand the nature of the universe and our place in it.

In short, human exploration and thinking about the universe also reminds us that despite the great progress made in science, the mysteries of the universe still require our continuous exploration and research.

●The evolution of the material structure of the universe is an extremely complex process, from order to disorder, and then to chaos or disorder. This process involves multiple structures such as dark matter, dark energy, supergiants, and super celestial bodies. The following is a discussion on the aspects you mentioned:

1. The evolution of the material structure of the universe: Since the Big Bang, the universe has experienced a process from high temperature and high density to gradual cooling and expansion. In this process, the material structure gradually formed complex structures such as galaxies, stars, and planets from a relatively uniform state. This process has both ordered components and disordered and chaotic components.

2. Dark matter and dark energy: These components dominate the universe, but their nature is not yet fully understood. The role of dark matter is to promote the formation of cosmic structure, while dark

energy causes the universe to expand faster.

3. Particles and chemical elements: With the advancement of science and technology, humans continue to discover new particles and chemical elements. These discoveries help us understand the composition and evolution of the universe.

4. The relationship between the structure of the earth and cosmic bodies: The structure of the earth has both homogeneous and heterogeneous aspects with other cosmic bodies. For example, elements on Earth are ubiquitous in the universe, but Earth's life activities and geological structures may be different on other celestial bodies.

5. Blind spots in human vision: Despite the great progress in science and technology, human cognition of the natural universe is still limited. Our current observation, experimentation and detection capabilities can only reach a small part of the universe.

6. Philosophy of science and cosmology: Although natural philosophy, philosophy of science, cosmology, particle physics, astrochemistry, astrobiology and other disciplines are closely related, their research methods and objects have different focuses and are not the same.

7. History of the universe and human history: The history of the universe is as long as trillions of years, while human history is relatively short. Despite this, humans have made remarkable achievements in less than 10,000 years of civilization, such as the development of Newtonian mechanics, quantum mechanics, particle physics, and landing on the moon and Mars.

In short, human cognition of the universe is a process of continuous exploration and deepening. Although our history is short, human

wisdom and rational power are constantly promoting the progress of science and technology, allowing us to gradually unveil the mysteries of the universe. In the future, as scientific research deepens, we have reason to believe that humans will better understand the nature of the universe.

●There are still many unknown areas in the current research on the evolution of cosmic material structure.

For example, the nature and specific mechanism of dark matter and dark energy are still unclear. Although we know that they play a key role in the evolution of the universe, we know little about the details of their composition, distribution and interaction.

There are also many mysteries in the formation and evolution of matter in the early universe, such as how the initial matter was produced and how the early microscopic particles formed the later macroscopic structure.

For example, our understanding of the material state and physical laws inside some extreme celestial bodies such as black holes and neutron stars is still quite limited.

In addition, whether there are other unknown elementary particles and interactions in the universe, as well as the precise details of the formation and evolution of the large-scale structure of the universe, also need to be further explored.

●Some new progress has been made in recent years in the study of the material state and physical laws inside black holes and neutron stars. Here are some relevant research results:

● Black hole:

○ Observations of the Event Horizon Telescope (EHT): The EHT collaboration provides detailed information about the vicinity of a black hole's event horizon through direct observations of black holes. These observations help verify and improve theoretical models of black holes.

○ Research on black hole mergers: Gravitational wave detectors have detected multiple black hole mergers, providing valuable data for studying the formation and merger process of black holes and the generation of gravitational waves.

○ Research on black hole thermodynamics: Researchers have conducted in-depth research on the thermodynamic properties of black holes, exploring concepts such as entropy and temperature of black holes, and their relationship with quantum mechanics.

● Neutron star:

○ Measurement of neutron star mass: Astronomers have accurately measured the mass of neutron stars by observing and analyzing their pulse signals. These measurements are of great significance for understanding the internal structure and physical processes of neutron stars.

○ Research on the state of matter inside neutron stars: Both theoretical and experimental research are exploring the state of matter inside neutron stars, such as superfluidity and superconductivity. These studies help reveal the peculiar properties and behaviors of neutron stars.

○ Interactions between neutron stars and other celestial bodies: Studying the interactions between neutron stars and companion stars, interstellar media, etc. is of great significance for understanding the formation and evolution of neutron stars and the

energy transfer and radiation mechanisms in the universe.

These are just some of the new advances in the field of black hole and neutron star research, which is still under development and exploration. Future research may further reveal the mysteries of black holes and neutron stars and provide us with a deeper understanding.

● Comprehensive analysis of the evolution of cosmic material structure and the boundaries of human cognition:

I. Evolution pattern of cosmic material structure

Dynamic balance of order and chaos

Local ordering: During the formation of galaxies (10^8-10^{10} M☉), gravity overcomes the expansion of the universe to form structures

Global entropy increase: In line with the second law of thermodynamics, the entropy of the universe has increased by about 10^{88} times since the Big Bang

Critical phase transition phenomenon: quark-hadron phase transition (10^{-6} seconds), photon decoupling (380,000 years) and other key nodes

Hierarchical construction model

Elementary particles → atomic nuclei → atoms → molecules → interstellar dust → star systems → galaxies → galaxy clusters → cosmic networks

Structure formation time scale: from Planck time (10^{-43} seconds) to the modern universe (13.8 Gyr)

II. Observational constraints on dark matter and dark energy

III. Extreme astrophysical phenomena

Supergiant evolution trajectory

Initial mass>8 $M_\odot$→Type II supernova→neutron star/black hole

Surface temperature and light curve: typical light variation amplitude $\Delta m_V \approx 15$ (such as SN 1987A)

Ultra-large scale structure

Sloan Great Wall: 423 million light years in length ($z \approx 0.078$)

Giant radio lobe: Centaurus A extends to 4.5 degrees of sky area

IV. Similarities and differences between element synthesis and matter

Nucleosynthesis process

Big Bang nucleosynthesis: H (75%), He (25%), Li trace ($t \approx 3$ minutes)

Stellar nucleosynthesis: CNO cycle (10^7 K), s-process (AGB star)

Supernova explosion: r-process (10^9 K, neutron flux>10^{22} cm^{-2} s^{-1})

Earth-universe composition comparison

Heavy element abundance difference: crustal Fe 5% vs interstellar medium Fe 0.1%

Abnormal isotope ratio: Earth $^{40}Ar/^{36}Ar \approx 298$ vs. the original value

of the solar system≈5.3

V. Bottlenecks and breakthroughs in observation technology

Frontiers of multi-messenger astronomy

Neutrino detection: IceCube observes PeV energy level events (such as TXS 0506+056)

Gravitational wave astronomy: LIGO-Virgo network positioning accuracy is improved to ~10 deg

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I. Evolution direction of cosmic material structure

Thermodynamic perspective: From the perspective of the law of entropy increase, the universe as a whole tends to be disordered (entropy increase), but ordered structures (such as galaxies and planetary systems) can be formed locally through energy exchange. The current universe is in a state of "coexistence of order and disorder".

Structure formation mechanism:

Hierarchical structure dominated by gravity (stars → galaxies → galaxy clusters)

Dark matter halos constitute the skeleton of the cosmic network

structure

Dark energy causes the universe to expand faster, which may eventually cause "heat death" (ultimate disorder)

Chaos theory confirms that small differences in initial conditions (such as quantum fluctuations) are amplified through inflation, forming the large-scale structures observed today.

2. Dark matter/energy and super celestial bodies

Characteristics of dark matter:

Accounting for 27% of the mass-energy of the universe, manifested through gravitational effects

May be composed of weakly interacting massive particles (WIMPs) or axions

Maintaining the rotation speed curve of galaxies and affecting the formation of the cosmic web structure

The essence of dark energy:

Accounting for 68%, driving the accelerated expansion of the universe

May be related to the dynamic changes of vacuum energy or quantum fields

Supergiant structures:

Discovering the "South Pole Wall" with a scale of more than 5 billion light years

Supermassive structures formed by quasar groups (such as the U1.27 quasar group)

Theoretical limits: the debate on whether the cosmological principle has been broken

3. Particle and element evolution

Frontiers of elementary particles:

62 particles of the standard model have been experimentally verified

New particles beyond the standard model (such as Majorana fermions) are being sought

Progress in dark matter detection in Jinping Underground Laboratory

Element synthesis process:

Big Bang nucleosynthesis (H, He, Li)

Stellar nucleosynthesis (C→Fe)

Supernova/r-process produces heavy elements (Au, U)

The laboratory has synthesized Og (element 118) and is looking for "stable island" elements

IV. Similarities and differences between the Earth and celestial bodies in the universe

Homogeneity performance:

Governed by the same physical laws

Element abundance conforms to the universal distribution of the universe (H>He>O>C)

Silicate mantle structure is common in terrestrial planets

Heterogeneity characteristics:

Earth's unique hydrosphere/biosphere

Plate tectonic movement is currently only confirmed on Earth

Atmospheric composition deviates significantly from the solar system average (21% oxygen)

The giant impact hypothesis of the formation of the moon reflects local particularity

V. Research blind spots and breakthroughs

Challenges of Human Exploration of the Space Environment

Humans face many challenges in the process of exploring the space environment. First, the radiation environment of space poses a threat to human health and safety. Long-term exposure to high doses of cosmic rays may cause cancer and other health problems. Second, the extreme temperature and pressure of space also pose a challenge to human survival. Finally, humans need to overcome technical difficulties, such as the propulsion of spacecraft, the maintenance of life support systems, and the reliability of communication technology.

●Achievements of Human Exploration of the Space Environment

Despite many challenges, humans have made remarkable achievements in exploring the space environment. For example,

humans have successfully sent probes to Mars and other planets for exploration and collected a large amount of scientific data. In addition, humans have established the International Space Station, which provides astronauts with a long-term living and working environment. These achievements not only demonstrate the scientific and technological strength of humans, but also lay the foundation for future space exploration.

In short, the impact of the space environment on life is multifaceted, and it may bring both benefits and harm. Humans need to continue to study the space environment in depth, explore more possibilities for survival, and prepare for future space exploration.

●The impact of cosmic rays on organelles involves the interaction between high-energy particles and biological molecules, mainly causing direct damage and indirect oxidative stress through the ionizing radiation effect. The following is a detailed analysis:

I. Composition and action pathways of cosmic rays

Cosmic rays are mainly composed of high-energy protons (89%), alpha particles (10%) and a small amount of heavy ions (1%)8, with an energy range from megaelectronvolts (MeV) to ultra-high energy levels (EeV). When these particles penetrate the Earth's atmosphere, they collide with atmospheric molecules to produce secondary particles (such as neutrons, gamma rays, etc.), forming ionizing radiation [[1]4. Although the atmosphere shields most of the primary rays, the remaining secondary radiation can still reach the surface and have potential effects on human cells.

II. Direct damage of ionizing radiation to organelles

Cell nucleus (DNA damage)

High-energy particles directly penetrate the cell nucleus and destroy the chemical bonds of the DNA chain through ionization, resulting in single-strand or double-strand breaks [[1]9. Studies have shown that protons and heavy ions in cosmic rays can cause irreversible damage to DNA, increase the risk of gene mutation, and even be associated with cancer and birth defects.

Mitochondria (mtDNA and functional abnormalities)

Mitochondria contain independent circular DNA (mtDNA), which lacks histone protection and is more sensitive to radiation. Cosmic rays can induce mtDNA mutations, leading to oxidative phosphorylation dysfunction, thereby reducing ATP production and increasing reactive oxygen species (ROS) release7. The accumulation of ROS further damages the mitochondrial membrane structure, forming a vicious cycle.

III. The effect of indirect oxidative stress on organelles

Ionizing radiation produces reactive oxygen species (such as ·OH, H_2O_2) by hydrolyzing water molecules in cells, causing lipid peroxidation, protein denaturation and nucleic acid damage:

Cell membrane and endoplasmic reticulum: Unsaturated fatty acids in the lipid bilayer are susceptible to ROS attacks, resulting in decreased membrane fluidity and changes in permeability, affecting material transport and signal transduction. Oxidative stress in the endoplasmic reticulum may interfere with protein folding and trigger the unfolded protein response (UPR).

Lysosomes and Golgi bodies: Oxidative damage can cause lysosomal membrane rupture, release hydrolases and trigger cell autolysis; damage to the membrane structure of the Golgi body affects the processing and transportation of secretory proteins.

IV. Physical damage of organelles by special particles

Heavy ions and microbeam effects

High-energy heavy ions (such as iron nuclei) in cosmic rays have high linear energy transfer (LET), which can form "microbeams" with extremely high local ionization density, directly destroying organelle structures. For example, physical rupture of mitochondrial cristae may lead to energy metabolism collapse3 (analogous to the silicon atom displacement mechanism in semiconductors).

Secondary reactions caused by neutrons

Although neutrons are not charged, they collide with hydrogen nuclei (such as protons of water molecules) in organisms to produce recoil protons or gamma rays, indirectly damaging organelles.

V. Protection and research progress

Natural protection mechanism

The antioxidant system in the human body (such as SOD and glutathione) can partially neutralize ROS and repair oxidative damage. In addition, DNA repair enzymes (such as PARP) can repair some breaks.

Artificial protection measures

Space mission protection: Astronauts use shielding materials (such as polyethylene) to reduce radiation exposure and take antioxidants (such as vitamins C and E) to relieve oxidative stress.

Ground research: Use accelerators to simulate cosmic rays and explore their specific damage mechanisms to organelles.

● Cosmic rays cause multi-level damage to organelles such as cell nuclei, mitochondria, and cell membranes through ionizing radiation and particle impacts. Its mechanisms include direct physical damage and indirect oxidative stress. Future research needs to further quantify the threshold of the impact of different types of particles on organelles and develop targeted protection strategies.

● Chemical changes usually also have the following characteristics:

1. Energy change: Chemical reactions are often accompanied by the absorption or release of energy. For example, combustion reactions release heat, while some endothermic reactions require the absorption of heat from the outside.

2. Color change: When a substance undergoes a chemical reaction, it may cause a change in color. For example, when iron reacts with copper sulfate solution, the solution gradually changes from blue to light green.

3. Precipitation: The reaction generates substances that are insoluble in the reaction system, thus forming a precipitate. For example, mixing sodium hydroxide solution and copper sulfate solution will produce a blue copper hydroxide precipitate.

4. Release of gas: New gaseous substances are generated and escape from the system. For example, carbonates react with acids to produce carbon dioxide gas.

5. Change of properties: The chemical properties of the substance change before and after the reaction. For example, hydrogen is flammable, but after reacting with oxygen to produce water, water is no longer flammable.

These characteristics can help us determine whether a process is a chemical change, but it should be noted that sometimes a change may have multiple characteristics at the same time, and sometimes there may be only one more obvious characteristic.

●The law of conservation of matter is a basic principle in classical physics, which states that in a closed system, the total mass of matter remains unchanged, that is, matter cannot be created or destroyed, but can only be converted from one form to another. However, the law of conservation of matter may appear to be "violated" in the following situations:

1. Microscopic scale: In quantum mechanics, the law of conservation of matter needs to be modified. For example, in some particle reactions, matter can be converted into energy and vice versa. This is described by the mass-energy equivalence formula $E=mc^2$, where E stands for energy, m stands for mass, and c is the speed of light. In particle physics, matter and antimatter can annihilate each other, producing energy.

2. Cosmic scale: In cosmology, the law of conservation of matter also needs to be reinterpreted in the face of the overall expansion of the universe. In the early stages of the universe, matter and radiation were the dominant components, but as the universe expanded, the density of matter decreased and the energy distribution became more uniform.

❤️
Some situations that may cause matter to seemingly "disappear":

Matter into energy: In particle physics, matter can be converted into energy. For example, an electron and a positron can annihilate each other when they meet, converting into two photons.

Dark matter and dark energy: In cosmology, dark matter and dark energy are two forms that do not emit light and do not interact with the electromagnetic force. Their existence may be an extension of the law of conservation of matter on a cosmic scale, as we do not yet fully understand their nature.

Black holes: Matter falling into a black hole may appear to "disappear" because the gravity of a black hole is so strong that not even light can escape. However, according to current understanding, matter does not really disappear, but is contained within the event horizon of the black hole.

Universal expansion: During the expansion of the universe, the density of matter and energy decreases, but this does not mean that matter is destroyed, but is distributed in a larger volume.

Quantum fluctuations: At the quantum scale, virtual particle pairs can briefly appear and disappear, which looks like the creation and destruction of matter, but is actually a normal phenomenon in quantum field theory and does not violate the law of conservation of matter.

In general, the law of conservation of matter is still a valid principle at the macroscopic scale, but under extreme conditions (such as the early universe, near black holes, quantum scale, etc.), we need more complex physical theories to describe the behavior of matter and energy. In these cases, the law of conservation of matter is not violated, but rather extended or modified by more comprehensive theories.

In quantum mechanics, matter transformation involves the interaction and transformation of elementary particles. Here are some examples and concepts of matter transformation in quantum

mechanics:

1. Annihilation of particles and antiparticles:

- In quantum field theory, matter particles (such as electrons) and their corresponding antiparticles (such as positrons) can meet and annihilate, transforming into energy. This process can be described by Einstein's mass-energy equivalence formula $E=mc^2$, where E is energy, m is mass, and c is the speed of light. During annihilation, the total mass of the particle and antiparticle is converted into an equal amount of energy, usually released in the form of photons.

For example:

$e^- + e^+ \rightarrow 2\gamma$

Here, an electron (e^-) and a positron (e^+) annihilate, producing two photons (γ).

2. Transformations in weak interactions:

- Weak interactions are one of the fundamental forces that allow certain types of particles to transform. For example, during beta decay, a neutron can transform into a proton, an electron, and an anti-electron neutrino:

$n \rightarrow p + e^- + \bar{\nu}_e$

Here, n represents neutron, p represents proton, e^- represents electron, and $\bar{\nu}_e$ represents anti-electron neutrino.

3. Transformations in the strong interaction:

- The strong interaction is responsible for combining quarks into hadrons such as protons and neutrons. In extremely high-energy

collisions, such as those in particle accelerators, quarks and gluons can recombine to form different particles. For example, a collision of two protons can produce a variety of different hadrons and leptons.

4. Higgs mechanism:

- In the Higgs mechanism, the Higgs field interacts with particles, giving them mass. In this process, the energy state of the particles changes, which can be seen as a form of material transformation.

5. Quantum fluctuations:

- In quantum field theory, the creation and annihilation of particle pairs occurs continuously even in a vacuum, as a result of quantum fluctuations. These particle pairs are short-lived and usually have no impact on the macroscopic world, but they demonstrate the dynamic transformation of matter and energy at the quantum scale.

6. Particle accelerator experiments:

- In particle accelerators, high-energy particle beams are used to hit a target or each other to create new particles. These experiments have verified many quantum mechanical processes of matter transformation, such as the creation of quarks and leptons, the decay and annihilation of particles, etc.

Matter transformation in quantum mechanics generally involves the following principles:

Energy conservation: In particle reactions, the total energy (including rest mass and kinetic energy) remains constant.

Momentum conservation: In particle reactions, the total momentum remains constant.

Quantum number conservation: Quantum numbers such as charge, isospin, and parity are generally conserved before and after reactions.

These transformation processes follow specific conservation laws and are precisely described by the mathematical framework of quantum mechanics. The standard model of particle physics is a theoretical framework that describes these transformations, which includes all known elementary particles and their interactions.

Energy conservation and momentum conservation are fundamental principles in physics, and they have a solid foundation in both classical mechanics and quantum mechanics. Here is an overview of how these principles are guaranteed:

Energy conservation

1. Noether's theorem: In quantum mechanics, energy conservation is a consequence of time translation symmetry. According to Noether's theorem, if a physical system is invariant under time translation (i.e., the laws of physics do not change over time), then the total energy of the system is conserved.

2 Hamiltonian mechanics: In classical mechanics, the Hamiltonian equations describe the evolution of a system, and the Hamiltonian (the total energy of the system) is ideally invariant over time. This means that the total energy of the system (kinetic energy plus potential energy) remains constant.

3. Schrödinger equation in quantum mechanics: In quantum mechanics, the time-dependent form of the Schrödinger equation describes the evolution of quantum states over time. The Hamiltonian operator in this equation corresponds to the total energy of the system, and the Schrödinger equation ensures that the

average value of the energy operator remains constant over time.

Conservation of momentum

1. Noether's theorem: Similar to conservation of energy, conservation of momentum is a consequence of spatial translation symmetry. If a physical system is invariant under spatial translation, then the total momentum of the system is conserved.

2. Newton's Third Law: In classical mechanics, Newton's Third Law (action and reaction are equal and opposite) ensures the conservation of momentum in a closed system. That is, the interaction forces between all objects in the system cancel each other out, so the total momentum remains unchanged.

3. Momentum operator in quantum mechanics: In quantum mechanics, the momentum operator is an observable quantity corresponding to momentum. In a closed system, the average value of the momentum operator does not change over time, which shows that the total momentum of the system is conserved.

Experimental verification

Experimental observation: The conservation of energy and momentum are verified by a large number of experiments and observations. These conservation laws have been repeatedly verified in particle collision experiments, astrophysical observations, and physical phenomena in daily life.

Restrictions

Non-ideal conditions: Under non-ideal conditions, such as open systems or in the presence of external forces, energy and momentum may not be conserved. For example, friction converts

mechanical energy into heat energy, which appears to violate the conservation of energy. But in fact, if we consider the entire system (including the environment and the heat energy generated by friction), energy is still conserved.

Relativistic effects: In relativistic physics, the conservation of energy and momentum still holds, but relativistic momentum and energy formulas are needed to describe them.

●In summary, the conservation of energy and momentum are fundamental principles in physics, and they are widely recognized and guaranteed through theoretical derivation and experimental verification. In closed systems, these conservation laws always hold, and they are the basis for understanding physical phenomena in nature.

The conservation of energy and momentum holds in most cases, but there are some special cases in which these conservation laws may not hold or need to be expressed in a more complex form:

1. Non-closed systems:

When a system is not closed, that is, when there is an exchange of external energy or momentum, the energy and momentum inside the system may not be conserved. For example, when an object is decelerated by friction, its kinetic energy is converted into heat energy, and the mechanical energy inside the system is not conserved, but if the entire system (including the earth and atmosphere) is considered, the energy is still conserved.

2. Relativistic speed:

When approaching the speed of light, the energy and momentum conservation laws of classical mechanics need to be expressed

through relativistic corrections. For example,